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REPORT ON A MILK-FLOW METER FOR PIPELINE SYSTEMS

By

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INTRODUCTION

The problem of measuring the milk production of individual cows on the farm by an economical, convenient, and accurate continuous flow method has been present for many years. In milking installations that utilize pipeline systems, the accepted method of weighing each cow's production becomes a definite chore and eliminates the saving in time and energy the pipeline system provides, especially in stanchion barns. It also introduces a change in routine on testing days which may have an effect on production. While production records are desirable for herd management and for herd improvement association records, some farms are evaluating the advantages of having production records against the disadvantages involved in obtaining them.

Since the installations of pipeline systems are increasing annually, the problem of measuring milk production by an economical, convenient, and accurate method becomes more acute every year. One method currently being used to weigh milk in pipeline systems involves a holding container which is suspended from a scale. Disadvantages of this method include the inconvenience of moving it from stanchion to stanchion with the milker unit and hoses, and disconnecting the hoses for each weighing as required by DHIA.

The present system of handling milk under vacuum presents a set of conditions which are unique in continuous flow metering. The problem is compounded by the rapidly varying flow rate, by the discontinuity of fluid flow, by the changing densities, and by the effect of air intermixing with the milk.

A flow meter (gravimetric weighing type) has recently become commercially available for measuring milk production of individual cows. This meter measures the milk in 1/4-pound increments and totals the increments so that the total production can be read on the face of the meter at the completion of milking. The meter operates in the milk line between the claw and the connection to the pipeline. This report concerns the milking

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tests which were conducted to determine the accuracy of this type meter as used in measuring milk production of individual cows.

EXPERIMENTAL PROCEDURES

Animals - Thirty cows in the Dairy Cattle Research Branch herd at Beltsville were involved in the trial. They consisted of 20 Holsteins, 3 Jerseys, and 7 crossbreds. Production of the animals ranged from 5 pounds to 44 pounds per milking. Stage of lactation ranged from 2 weeks to 12 months with an average of 6 months in milk. Ten of the animals in the trial were in their first lactation, six in their second, third, or fourth lactation, and fourteen were mature cows.

The thirty cows were milked in three groups of ten each. The grouping of the cows was based on location in the barn and convenience of the milking operation. Each group was milked for three consecutive milkings during each of the two weeks of the trial (May 5th to 17th). The first of the three consecutive milkings (P.M.) was a trial for the purpose of conditioning the cows to the equipment. The second milking was made in the morning to obtain total milk weight. The third milking was made in the afternoon to obtain flow rate and total weight data.

Equipment - A portable vacuum system on a four-wheel dolly provided a constant vacuum independent of the barn vacuum system. This portable vacuum system consisted of a vacuum pump, vacuum controller, vacuum gage, a sanitary trap, and a magnetic pulsator. The vacuum controller regulated the system to 12 inches (Hg) of vacuum.

A second four-wheel dolly was constructed to hold the weighing devices and a small inclined desk top for recording data. A locking device and a leveling method were used on the weight dolly to provide stability and balance. The weighing devices included a new 100-pound capacity precision bench scale with a 20-inch-diameter dial graduated in 1/10-pound increments. This scale was checked and approved by the Prince Georges County (Md.) Department of Weights and Measures on May 2nd and May 20th (immediately prior to and on completion of the tests). The scale was found to be accurate to ±0.02 pound at both times. A standard spring milk scale was also used for comparative weight readings.

The milk meter used in this study was a commercial model calibrated at a flow rate of 4 pounds per minute by the manufacturer. The meter was rigidly fastened to pipes anchored to the dolly. These pipes also provided supporting hooks to hold the spring scale and the milk pail lid during the final weighings.

TEST PROCEDURES DURING MILKING

One man was selected to do all the milking of the cows in this test. The weight dolly and vacuum dolly were positioned behind the cow to be milked. (See Figure 1). The weight dolly was leveled, the meter was

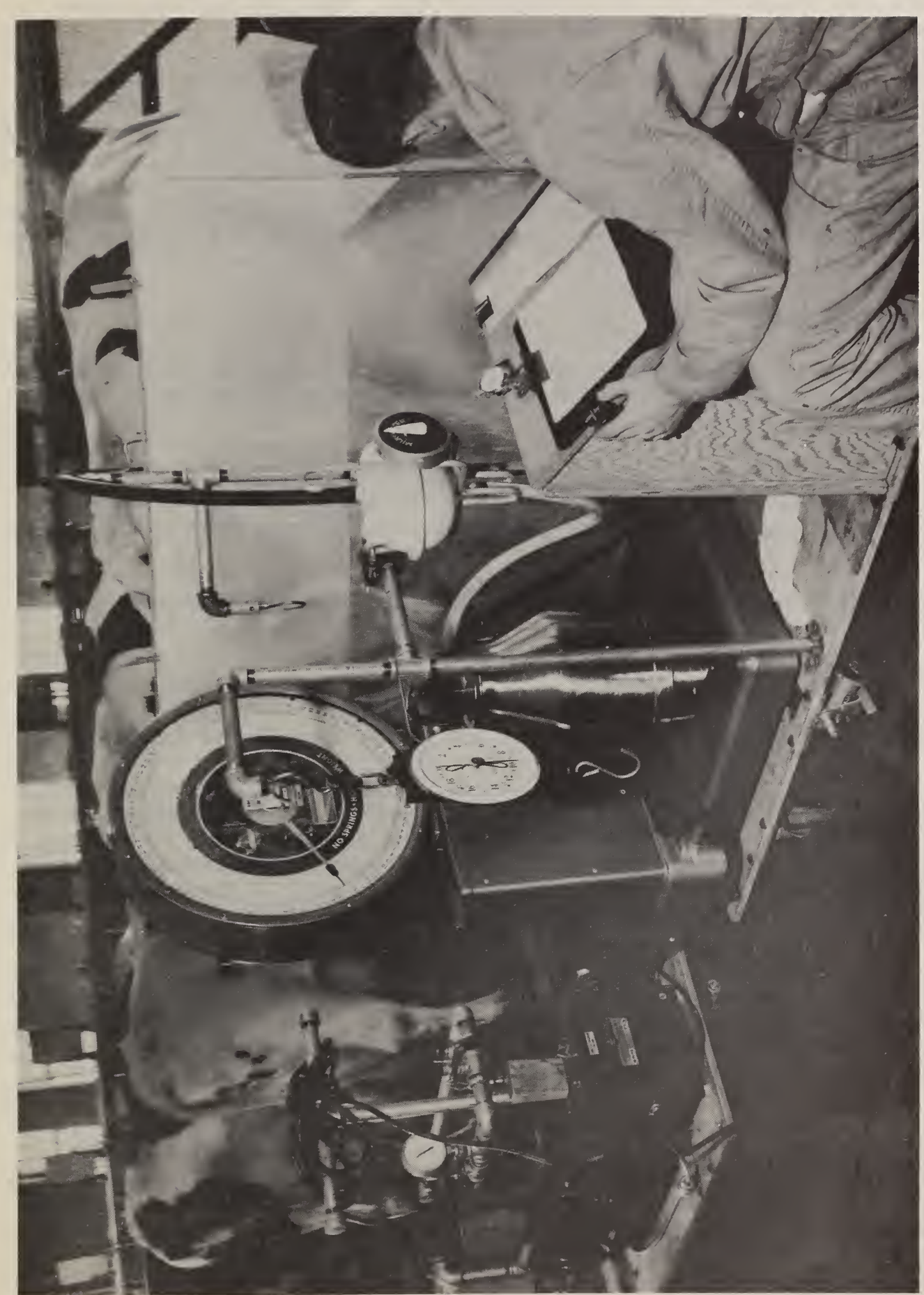

FIGURE 1.

checked for level, the bench scale checked for zero, and the empty milk pail was weighed prior to milking each cow. Time was measured by a stopwatch while the teat cups were on the udder.

The meter and bench scale weights were read and recorded at the end of each milking, before, and after the meter was manually tripped to remove the remaining milk. The final weight of the pail and milk, with the lid removed, was read on the bench scale and on the spring scale, and recorded. The final weight reading on the bench scale, which included the residue from the manual trip of the meter, was recorded as the check weight. The final meter reading, observed after manual tripping, was recorded as the meter weight.

TREATMENT OF DATA

The weight as determined by the spring scale was used for the purpose of determining the agreement or discrepancy between a bench scale and a typical milk scale.

The average rate of flow used in this analysis consisted of the meter weight at the first 15-second interval yielding less than 1/4 pound, divided by the length of time (minutes) from start of flow to this point.

Detailed statistical analysis was completed by Biometrical Services, ARS.

RESULTS AND DISCUSSION

An examination of the results of these trials reveals the following:

1. The daily milk weights for the 30 cows (Table 1) varied from 10.40 to 78.40 pounds and averaged 35.18 pounds (standard deviation = 15.36 pounds). The average rate of milking for individual cows (Table 2) varied from 1.4 to 5.0 pounds per minute and averaged 3.0 pounds per minute (standard deviation = 0.88 pound per minute). The maximum rate for any one 15-second interval was 11 pounds per minute.

2. Milk weights as determined by the meter contained a bias or error which was highly significant statistically and generally negative. The differences between bench scale and meter weights for individual milkings ranged from +0.60 pound to -1.95 pounds, and from +3.2% to -6.3%. The average of these differences was 0.46 pound.

3. The differences between bench scale and meter for daily milk weight (Table 1) varied from +0.55 pound to -3.70 pounds (standard deviation = 0.83 pound), and from +2.09% to -5.15% (standard deviation = 1.69%). Twenty percent of the daily milk weights provided by the meter averaged 4.13% less than the balance weights, and fifty percent of the daily milk weights averaged 3.34% less than the balance weights.

TABLE 1

DAILY MILK WEIGHTS AND METER ERRORS

Cow No.	FIRST WEEK				SECOND WEEK			
	Scale Weight #	Meter Weight #	Meter Error * #	Meter Error * %	Scale Weight #	Meter Weight #	Meter Error * #	Meter Error * %
GROUP I								
SX-297	34.80	33.50	1.30	3.74	33.55	32.25	1.30	3.87
X-616	29.55	28.50	1.05	3.55	28.35	27.50	0.85	3.00
X-612	28.95	27.75	1.20	4.15	29.05	28.25	0.80	2.75
3233	24.15	23.50	0.65	2.69	22.45	21.50	0.95	4.23
3232	15.35	15.25	0.10	0.65	10.90	11.00	+0.10	+0.92
3235	33.40	32.25	1.15	3.44	27.20	26.50	0.70	2.57
X-625	49.55	47.00	2.55	5.15	47.05	46.25	0.80	1.70
SX-289	26.20	26.00	0.20	0.76	24.50	24.25	0.25	1.02
SX-298	26.50	25.50	1.00	3.77	29.15	28.50	0.65	2.23
SX-299	23.45	23.25	0.20	0.85	22.80	22.75	0.05	0.22
GROUP II								
3058	38.00	36.75	1.25	3.29	33.65	33.25	0.40	1.19
3083	19.85	20.25	+0.40	+2.02	16.40	16.75	+0.35	+2.13
3086	13.40	13.50	+0.10	+0.75	10.40	10.50	+0.10	+0.96
2406	56.70	55.75	0.95	1.68	62.30	60.25	2.05	3.29
3000	50.55	49.25	1.30	2.57	53.35	52.50	0.85	1.59
2877	38.15	37.25	0.90	2.36	41.05	40.75	0.30	0.73
3008	32.25	32.50	+0.25	+0.78	37.45	37.00	0.45	1.20
2896	50.80	50.25	0.55	1.08	54.70	53.00	1.70	3.11
3006	47.20	45.75	1.45	3.07	44.75	44.25	0.50	1.12
2463	26.70	26.50	0.20	0.75	27.40	27.25	0.15	0.55
GROUP III								
3043	44.70	45.25	+0.55	+1.23	37.75	37.00	0.75	1.99
3003	57.00	55.25	1.75	3.07	55.80	53.00	2.80	5.02
2482	78.40	75.50	2.90	3.70	77.95	74.25	3.70	4.75
2865	25.15	24.75	0.40	1.59	22.15	21.50	0.65	2.93
3405	28.95	28.50	0.45	1.55	26.25	26.00	0.25	0.95
2887	19.15	19.00	0.15	0.78	16.40	16.00	0.40	2.44
3060	58.95	57.25	1.70	2.88	56.55	54.50	2.05	3.63
2870	38.20	37.50	0.70	1.83	32.30	31.00	1.30	4.02
2446	34.10	33.50	0.60	1.76	33.10	32.25	0.85	2.57
2842	23.70	23.50	0.20	0.84	24.35	23.75	0.60	2.46

* All meter errors are negative except where positive sign (+) is found.

TABLE 2

METER ERRORS AND AVERAGE FLOW RATES

Cow No.	FIRST WEEK				SECOND WEEK			
	Average Flow Rate #/min.	Milk Weight PM only #	Meter Error * #	Meter Error * %	Average Flow Rate #/min.	Milk Weight PM only #	Meter Error * #	Meter Error * %
GROUP I								
SX-297	2.95	15.70	0.20	1.27	3.10	17.50	0.50	2.86
X-616	4.33	13.85	0.35	2.53	5.00	14.00	0.50	3.57
X-612	3.69	12.85	0.35	2.72	3.33	13.65	0.40	2.93
3233	3.50	10.20	0.20	1.96	3.25	10.45	0.20	1.91
3232	2.91	9.85	0.10	1.02	1.89	5.70	+0.05	+0.88
3235	3.40	13.90	0.15	1.08	3.17	10.50	0.25	2.38
X-625	3.07	21.95	0.70	3.19	3.39	25.10	0.85	3.39
SX-289	2.25	11.60	+0.15	+1.29	2.44	11.40	0.15	1.32
SX-298	2.14	12.45	0.20	1.61	2.26	13.55	0.05	0.37
SX-299	1.41	10.75	0.00	0.00	1.46	10.20	+0.05	+0.49
GROUP II								
3058	4.85	17.50	0.75	4.29	4.00	16.00	0.25	1.56
3083	1.85	9.45	+0.30	+3.17	1.47	6.65	+0.35	+5.26
3086	2.50	7.70	+0.05	+0.65	1.78	4.60	+0.15	+3.26
2406	3.50	25.20	0.20	0.79	3.81	27.40	1.15	4.20
3000	3.17	19.95	0.20	1.00	3.46	22.60	0.60	2.65
2877	2.28	17.75	0.75	4.23	2.54	17.55	0.05	0.28
3008	2.77	15.05	+0.45	+2.99	3.00	16.60	0.10	0.60
2896	3.32	23.60	+0.15	+0.64	2.85	25.80	0.80	3.10
3006	2.41	23.30	0.30	1.29	2.53	21.35	0.35	1.64
2463	2.39	11.95	+0.05	+0.42	2.50	11.50	0.00	0.00
GROUP III								
3043	1.73	19.15	+0.60	+3.13	1.68	18.85	0.10	0.53
3003	3.81	25.55	0.55	2.15	3.25	27.65	1.15	4.16
2482	4.05	43.90	1.40	3.19	3.13	36.92	1.95	5.28
2865	2.76	12.15	0.15	1.23	3.33	12.40	0.40	3.23
3405	3.65	16.35	0.35	2.14	2.69	11.15	+0.10	+0.90
2887	2.06	9.55	0.05	0.52	2.31	8.75	0.25	2.86
3060	4.89	24.10	0.60	2.49	4.27	26.30	1.05	3.99
2870	4.50	19.80	0.30	1.52	3.05	15.50	0.75	4.84
2446	2.57	15.00	0.00	0.00	2.00	13.70	0.20	1.46
2842	2.33	9.70	+0.05	+0.52	2.35	10.80	0.30	2.78

* All meter errors are negative except where positive sign (+) is found.

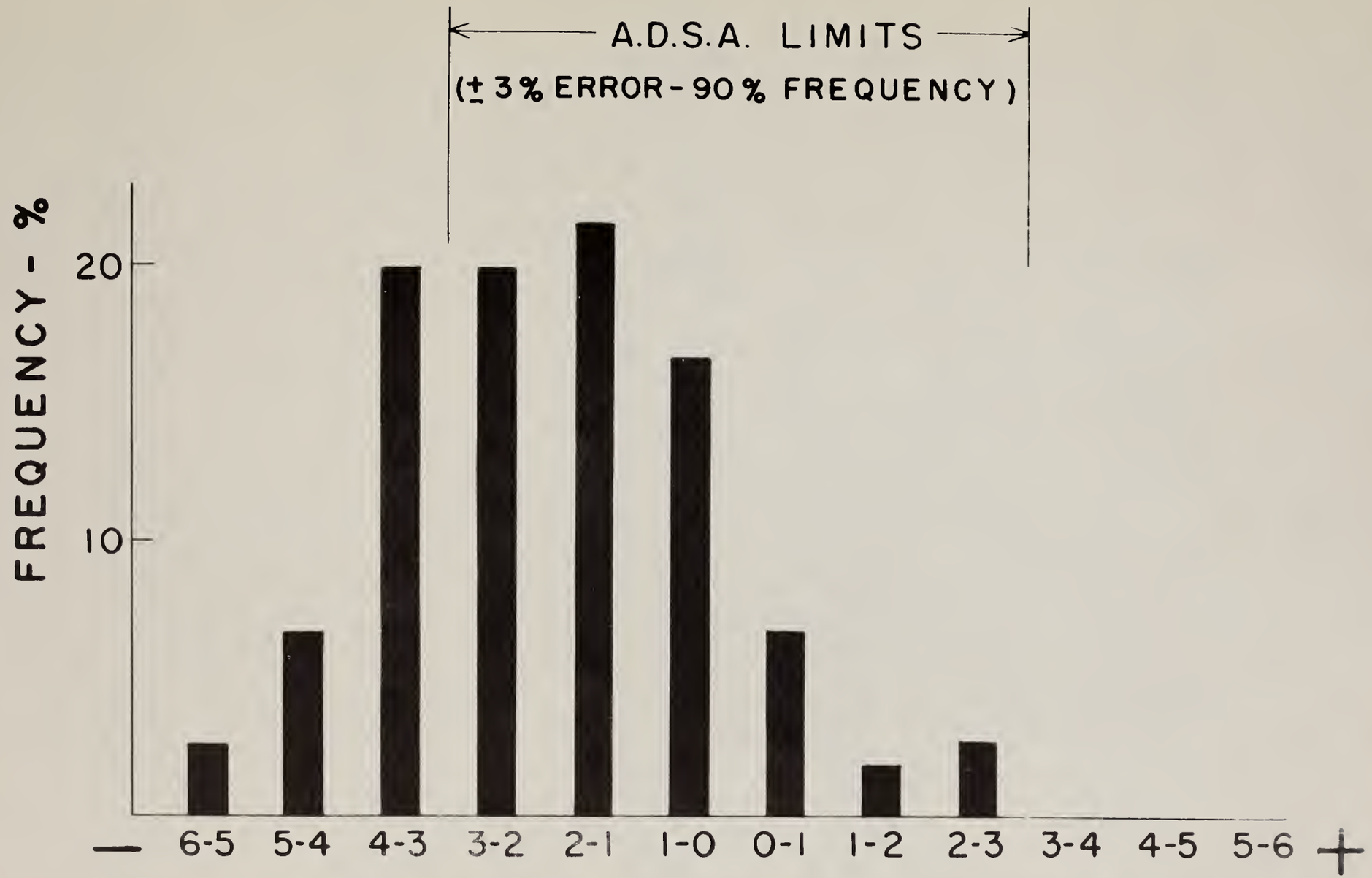

Fig. 2 - DAILY MILK WEIGHT ERRORS - %

4. The meter weights exceeded the balance weights in 7 of the 60 daily milk weights (11.7%) and were less than the balance weights in 53 of the 60 daily milk weights (88.3%). On the basis of total daily production, 47% of the weights were within ±2% error, 70% were within ±3% error, 90% were within ±4% error, and 10% were above ±4% error. (See Figure 2).

5. The repeatability of these differences for the same cows was between .6 and .7, which indicates that a large proportion of these differences were peculiar to cows and not random. The results clearly show that the milk yields of high producers and faster milkers was underestimated, while the milk yields of low producers and slow milkers was overestimated.

6. The correlation between average yields in two milkings of individual cows and the error was -.86. The negative sign of the correlation indicates that the error increased negatively as the total yield increased.

7. The spring scale used in this test agreed with the precision bench scale within 0.05 pound for 93% of the weight readings. A complete report of this and other milk scales is found in ARS 42-13, October, 1957. The maximum difference noted was .20 pound at 41 pounds total milk weight.

In view of the rather high correlation between rate of flow and volume of production and the possible inheritance of these traits, the influence of these factors on the presence and size of any error in the record should be considered, not only from the standpoint of the individual record, but also from the standpoint of biasing sire provings.

In these tests, every known precaution was taken to obtain the highest possible accuracy. It is expected that under normal barn conditions the accuracy would be somewhat less than that obtained in this study.

If the calibration of the meter had been shifted to a higher flow rate, it is possible that for these tests, the meter would have been accurate to ±3%, but the error would still have been non-random. Adjustment of meter calibration would require flow rate information for individual herds, and for individual cows in certain cases.

SUMMARY

A trial involving 30 cows and 120 milkings was conducted to determine the accuracy of a milk-flow meter as used in measuring milk production of individual cows. The bias of the meter was negative and statistically significant. The production of heavy and fast milking cows was underestimated to a greater extent than that of light and/or slow milkers.